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TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
3		

4. Title and Subtitle	5. Report Date
Sea-Surface Circulation, Sediment Transport, and Marine Mammal Distribution, Alaska Continental Shelf.	February 20, 1973
	6. Performing Organization Code
7. Author(s) Sharma, G. D., F. F. Wright and J. J. Burns	8. Performing Organization Report No.
9. Performing Organization Name and Address Institute of Marine Science University of Alaska Fairbanks, Alaska 99701	10. Work Unit No.
	11. Contract or Grant No. NAS5-21833
12. Sponsoring Agency Name and Address NATIONAL AERONAUTICS AND SPACE ADMINISTRATION Goddard Space Flight Center Greenbelt, Maryland 20771 Technical Monitor: Mr. Edward C. Crump, Code 430	13. Type of Report and Period Covered Type II July 1972–January 1973
	14. Sponsoring Agency Code

15. Supplementary Notes

One of 12 ERTS-1 projects conducted by the University of Alaska
ERTS-1 project, GSFC No. 110-8
Principal Investigator. GSFC ID No. UN 683

16. Abstract

The objectives of this project are to trace sea water and sediment movements, and observe the factors controlling sea mammals distribution from ERTS-1 multispectral scanner imagery.

During the reporting period effort was made to obtain ground truth observations from Cook Inlet synchronous to the overhead satellite pass. Data from Cook Inlet was collected during August and September 1972. Based on the data a general water circulation pattern in this area is proposed. The general circulation shows a striking similarity to the pattern obtained by ERTS-1 imagery received during early November.

From the ERTS-1 imagery it was possible to delineate and describe the various types of ice ranging from "grease ice" to heavy flows of disintegrated shore-fast ice.

17. Key Words (Selected by Author(s))	18. Distribution Statement
ERTS Imagery Remote Sensing Sea Surface Circulation on Alaskan Shelf Sea Mammal Habitat Sea Ice Distribution	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified		4.00

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I. INTRODUCTION

The purpose of this project has been to trace water and sediment movements, and observe the factors controlling sea mammal distribution from ERTS multi-spectral scanner imagery. Emphasis during the first half year of this project has been upon data from the Cook Inlet area of southern Alaska and from the Bering Sea and Chukchi Sea of the northwest (Fig. 1). Relatively, both these areas are accessible for ground truth observations, and the weather has permitted the collection of useful ERTS imagery. The Bristol Bay area has also provided satisfactory imagery and it is anticipated that information from the extreme eastern end of this area will be available in useful quantities.

This report will emphasize the interpretation of the Cook Inlet materials, both to "ground truth" and to non-synchronous imagery, for it has become very clear that these data supplement each other in a very useful fashion. It is hoped that truly synchronous observations will ultimately be made as a final check, but as a working hypothesis it has been assumed that general circulation patterns are consistent in Cook Inlet with time and that, except in detail too fine for ERTS registration, the ERTS images can, on a seasonal basis, be used to interpret and expand the ground truth data.

The major effort during the reporting period was to obtain synchronous ground truth and satellite imagery. This is pertinent to the total understanding of the ERTS-1 imagery. Undoubtedly the sediments in the water column as observed from the ERTS imagery reflect the sources and movement of sediments and thereby elucidate the coastal sea surface

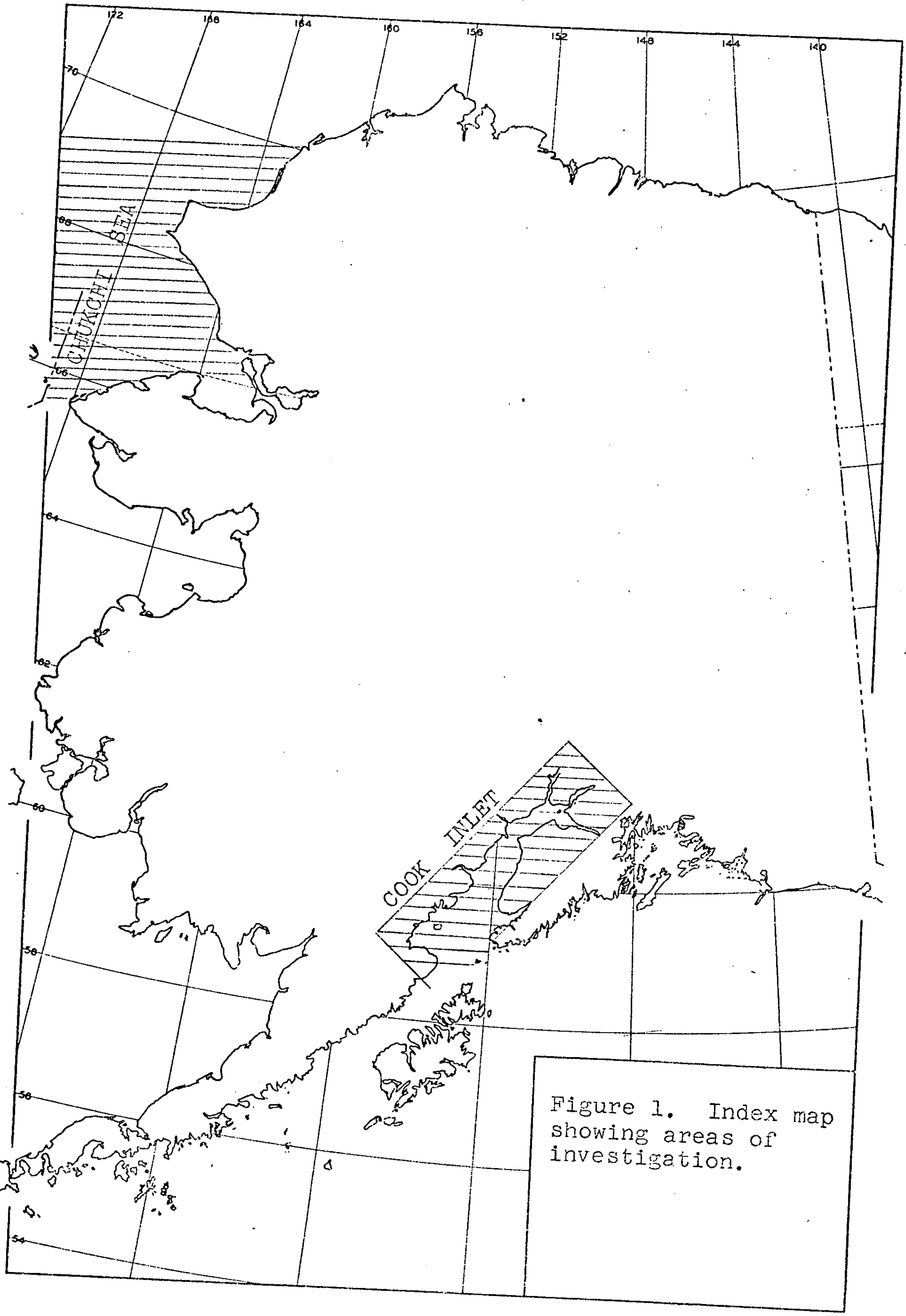

Figure 1. Index map showing areas of investigation.

circulation pattern. Detailed interpretation of sediment distribution and water circulation on the entire shelf, however, requires a more cautious approach. The turbid water as observed in the ERTS-1 imagery could be a result of biological material as well as sedimentary material. The source for planktonic biological matter is sea water and its distribution and concentration may vary almost daily. The sedimentary material, on the other hand, originates along the shores, primarily from rivers but also from other factors such as shoreline erosion. The relative effects of biological and sedimentary suspended material on the ERTS-1 imagery obtained in the various bands are required in order to conduct detailed analysis and interpretation of ERTS-1 data. In view of the importance of correlating ground truth with synchronous overhead satellite passes, our major effort was directed to achieve this goal. Since positive (synchronous) correlation of ERTS-1 imagery and ground truth is considered the most important objective of this project, the limited budget for processing ERTS-1 imagery has made it necessary for us to restrict extensive photographic processing to only those images for which reasonably adequate ground truth data is available.

A. Cook Inlet Studies

The program was initiated in Cook Inlet where two attempts (22-25 August 1972 and 25-29 September 1972) were made to obtain synchronous ground truth data. Unfortunately, extensive cloud cover did not permit ERTS-1 to obtain useful imagery from this area. Excellent ERTS-1 imagery was obtained for Cook Inlet on 4 November 1972, however, no ground truth collection had been planned due to the low sun angle and because the area is generally under heavy cloud cover during this time of the year.

The field data obtained in Cook Inlet and described here did, however, serve three purposes: 1) The general water circulation pattern in lower Cook Inlet is consistent throughout the Fall season, 2) ERTS-1 images in MSS bands 4 and 5 are capable of delineating water masses with a suspended load as low as 1 mg/ℓ and 3) the information will serve as baseline data for future ERTS-1 imagery.

In order to increase our chances of obtaining synchronous data we plan to collect ground truth data from additional regions and have requested additional ERTS-1 imagery to cover the proposed regions.

B. Bering Sea and Chukchi Sea

The seasonal pack ice of the Chukchi and Bering Seas is one of the most important and dominating features of the western sub-Arctic marine system. The seasonal advance and retreat of sea ice directly influences (possibly controls?) such basic aspects as vertical water stability, sea water temperature, light penetration and available growing substrate for primary production by alga. Sea ice also directly influences the seasonal movements, distribution and density of fishes and marine mammals of the region.

To date, the vast majority of sea ice research has been directed toward studies of the physical properties, physics, tectonics and engineering aspects of the polar ice caps with very little effort directed toward seasonal sea ice. This project is specifically directed toward the formation and movement of seasonal sea ice.

C. Kuskokwim Bay and Nushagak Bay Studies

Excellent ERTS-1 images (ID Nos. 1039-21371 and 1054-21203) from Kuskokwim Bay and Nushagak Bay provided the opportunity to study the nature and extent of suspended sediment plumes in these areas. The surface currents and the effects of Coriolis force are clearly indicated in these images.

II. STATUS OF PROJECT

A. Objectives

The overall objectives of this study are to delineate the general surface water circulation, transport of surface sediments and characteristics of sea ice. The study includes observation of the geographical distribution of silt-laden coastal waters of Alaska. After a positive correlation between ERTS-1 imagery and the ground truth is accomplished, estimates of amounts of sediments carried offshore annually from Alaska will be made. The general movements of water on the shelf will be delineated using suspended load as a tracer.

Sea ice characteristics and seasonal changes in area coverage of sea ice will be studied from the standpoint of: a) ice type (land-fast vs. drifting pack); b) condition of ice (age, degree of deformation, snow cover); c) ocean surface coverage; and d) relationships of ice characteristics to observed biological phenomena. These parameters will then be related to sea mammals and polar bear ecology, resource utilization and surface circulation. Permanent and semi-permanent leads and polynyi in the sea ice will be traced and their locations recorded.

B. Accomplishments During the Reporting Period

1. Preliminary Investigations

a. Cook Inlet

The logistics of any oceanographic operation are complex, and scheduling becomes an exercise in optimizing many erratic variables. In the case of ground truth collection for the ERTS project in Cook Inlet, cruises were scheduled to approximately coincide with ERTS orbits for the latter part of August and the end of September. The ship time for the September R/V ACONA cruise was provided by the Institute of Marine Science at no cost to the ERTS 110-8 project. In August, research was accomplished using a chartered 26 ft work boat from the port of Homer (a small University vessel had been reserved, but broke down just before we were due to take it out). This chartered boat proved excellent for surface water sampling, for it was capable of 25-30 knots, permitting very rapid coverage of the study area. A series of stations extending from Homer to the bifurcation of the inlet near Anchorage were obtained on 22-23 August (Fig. 2). At the same time, however, living space was exceedingly limited, working space was minimal, and laboratory space was nil aboard the vessel. In essence, the August cruise became simply a very quick reconnaissance to assess the general characteristics of the Inlet at this season. In September the University's R/V ACONA was used to conduct a much more comprehensive study throughout

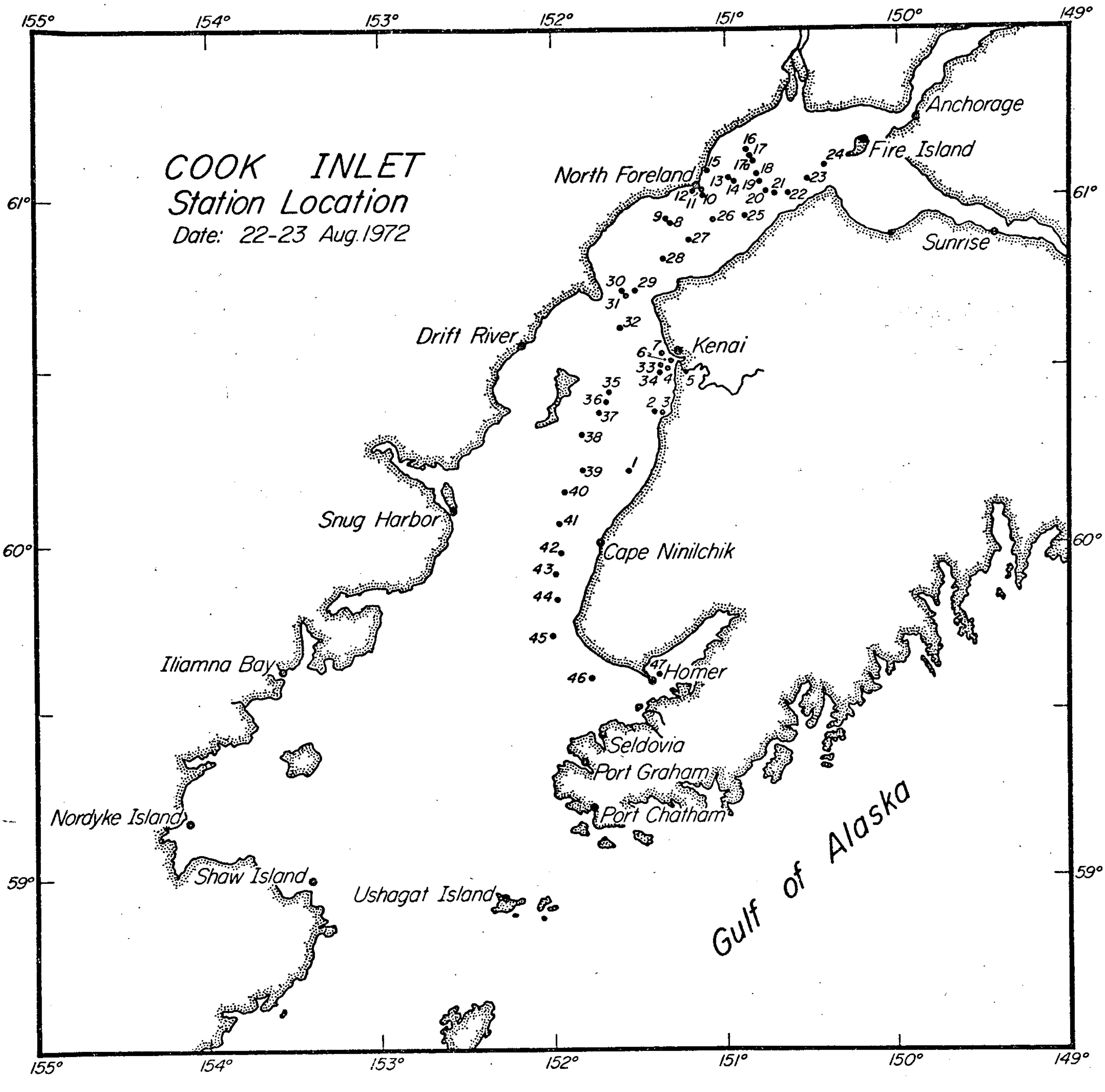

Figure 2. Station locations for sampling in Cook Inlet, Alaska; 22-23 August 1972.

the Inlet. Because of ACONA's speed (approximately 8 kts.), stations cover a much longer time span (25-29 Sept.); but because of improved working conditions, data could be collected much more easily and comfortably (Fig. 3). As it happened, both during August and September, ERTS observations in the Cook Inlet area were unusable; the cloud cover of the Inlet was over 70% on both occasions. On both August and September cruises, the basic ground truth data obtained consisted of temperature and salinity profiles of the upper segment of the water column (routinely to a depth of 12 m, at meter intervals) and the collection of a water sample for filtration and measurement of suspended sediment load. The temperature and salinity data were collected with a Beckman RS5-3 in situ Salinity Probe with relative (not absolute) accuracy to ±0.05 $^{o}/oo$ salinity or ±0.05°C. In such an estuary as Cook Inlet where there is tremendous variability in water characteristics, such instruments yield acceptable data without correction; for serious dynamical calculations where variability is small, they are less suitable. Suspended sediment samples were bottled and returned to the lab where they were filtered with standard Millipore membrane filtration apparatus on HA filters (0.45 microns). The data from these cruises for the water surface are shown in Figures 4-9.

b. Chukchi Sea

For sea ice study data from ERTS-A, in the form of photo imagery, was available during the period from 1 August to 4 November, 1972. However, only photos of 2, 3 and 4 August and 18 October, 1972, provided usable information with respect to seasonal sea ice. The seasonal ice regime in the study area involves the formation of sea ice in, and movement into

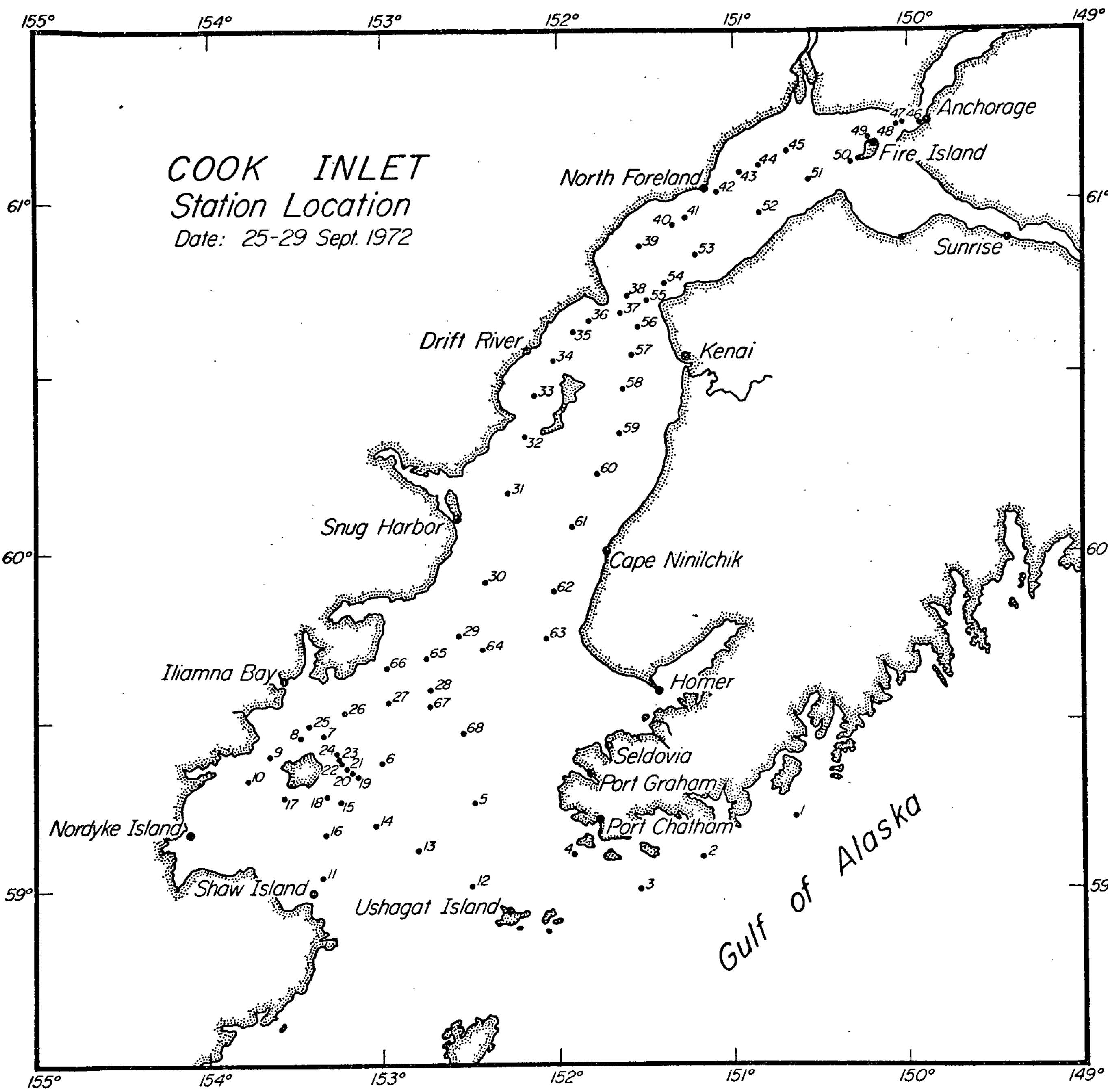

Figure 3. Station locations for sampling in Cook Inlet, Alaska; 25-29 September 1972.

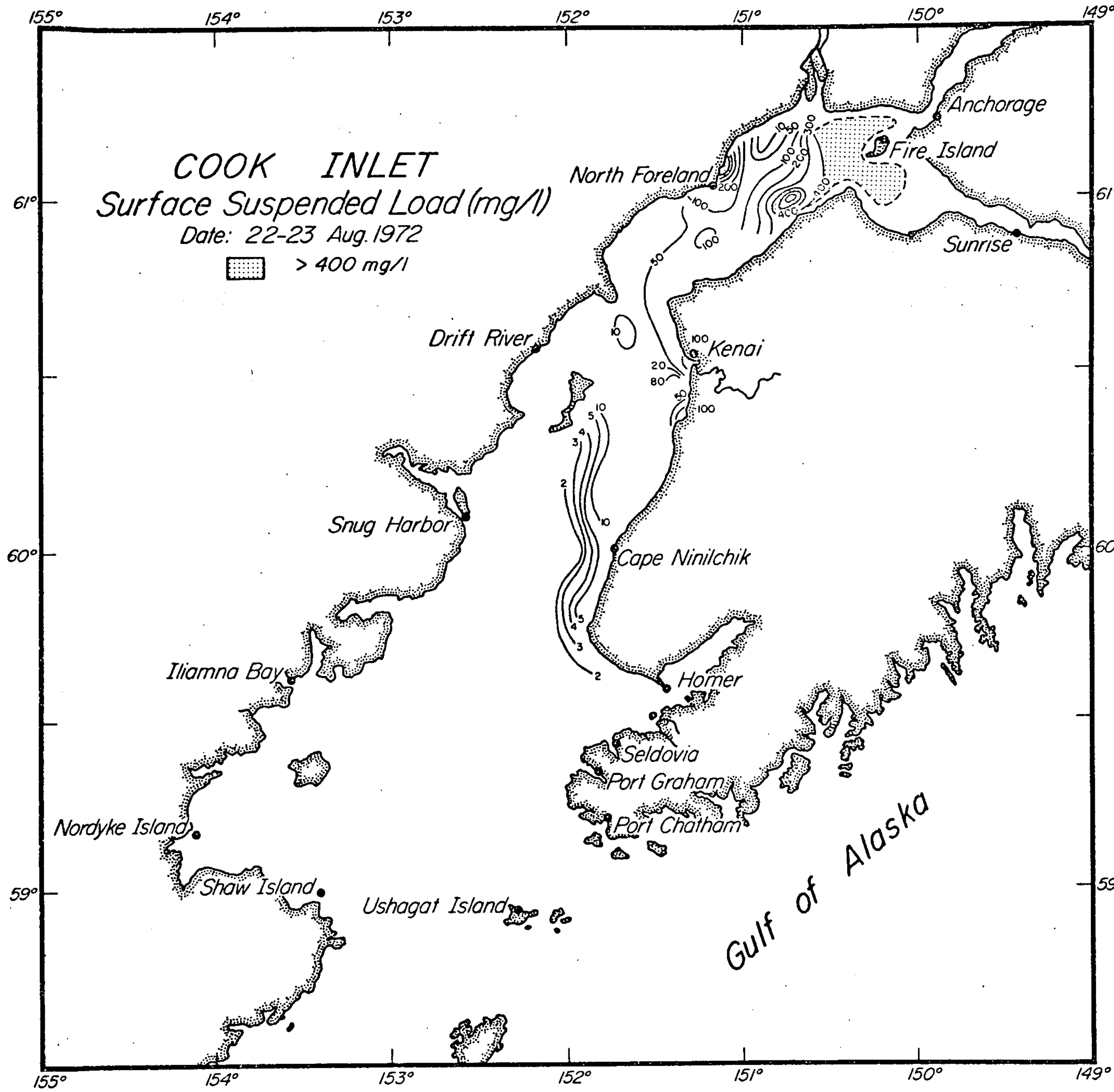

Figure 4. Suspended load distribution (mg/l) in surface waters of Cook Inlet, Alaska during 22-23 August 1972.

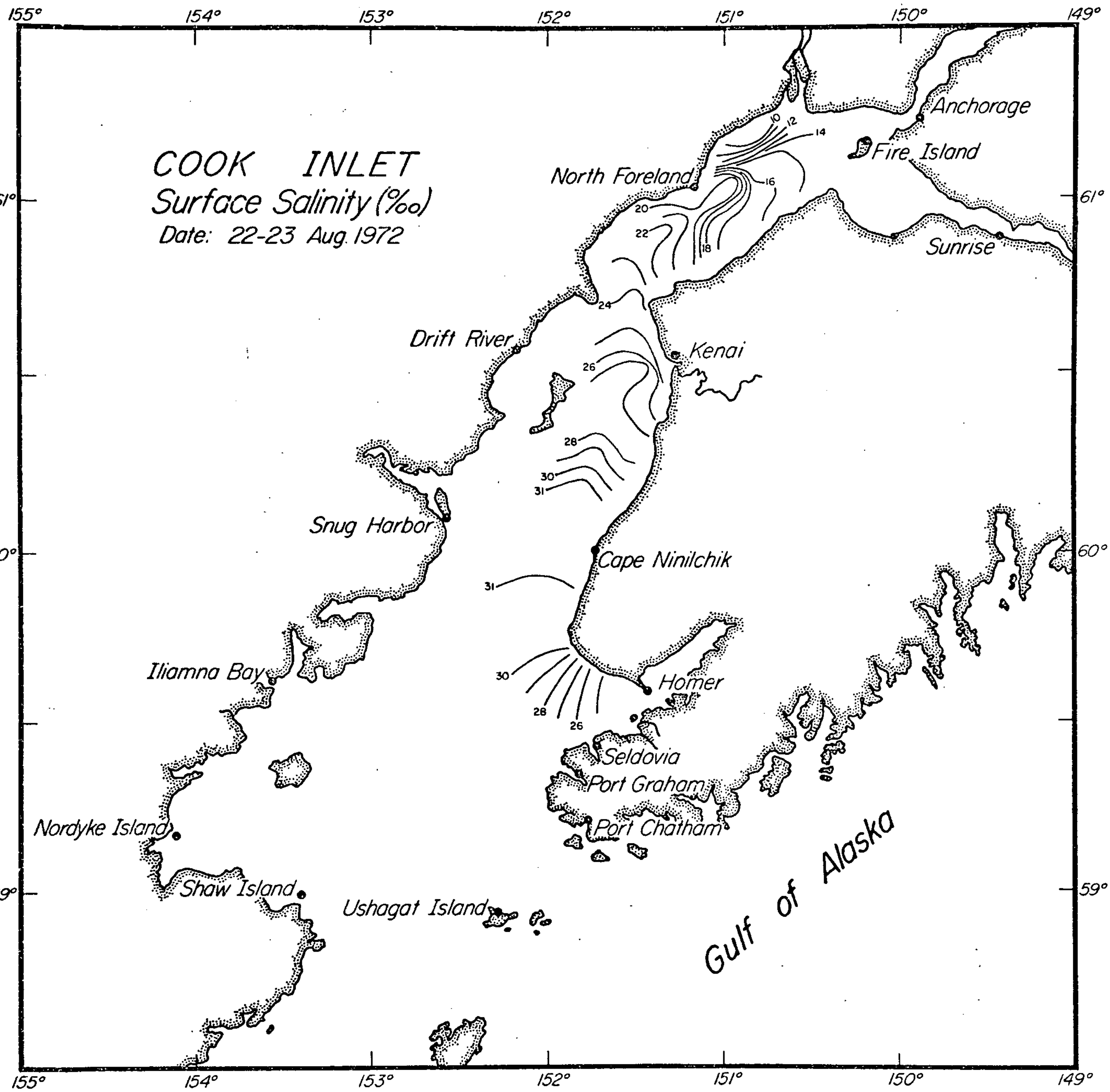

Figure 5. Surface water isohalines ($^{o}/oo$) in Cook Inlet, Alaska; 22-23 August 1972.

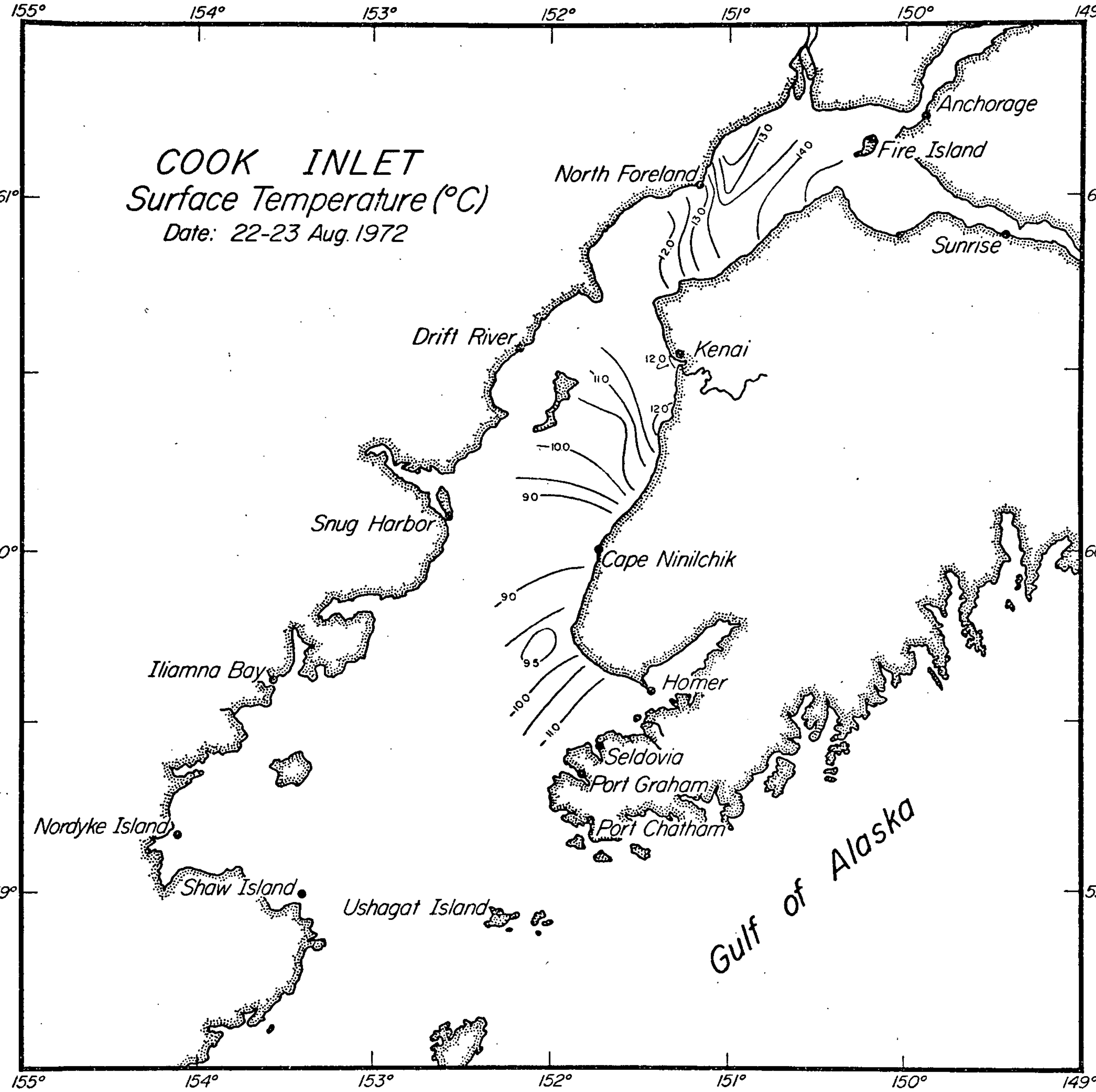

Figure 6. Surface water isotherms (°C) in Cook Inlet, Alaska; 22-23 August 1972.

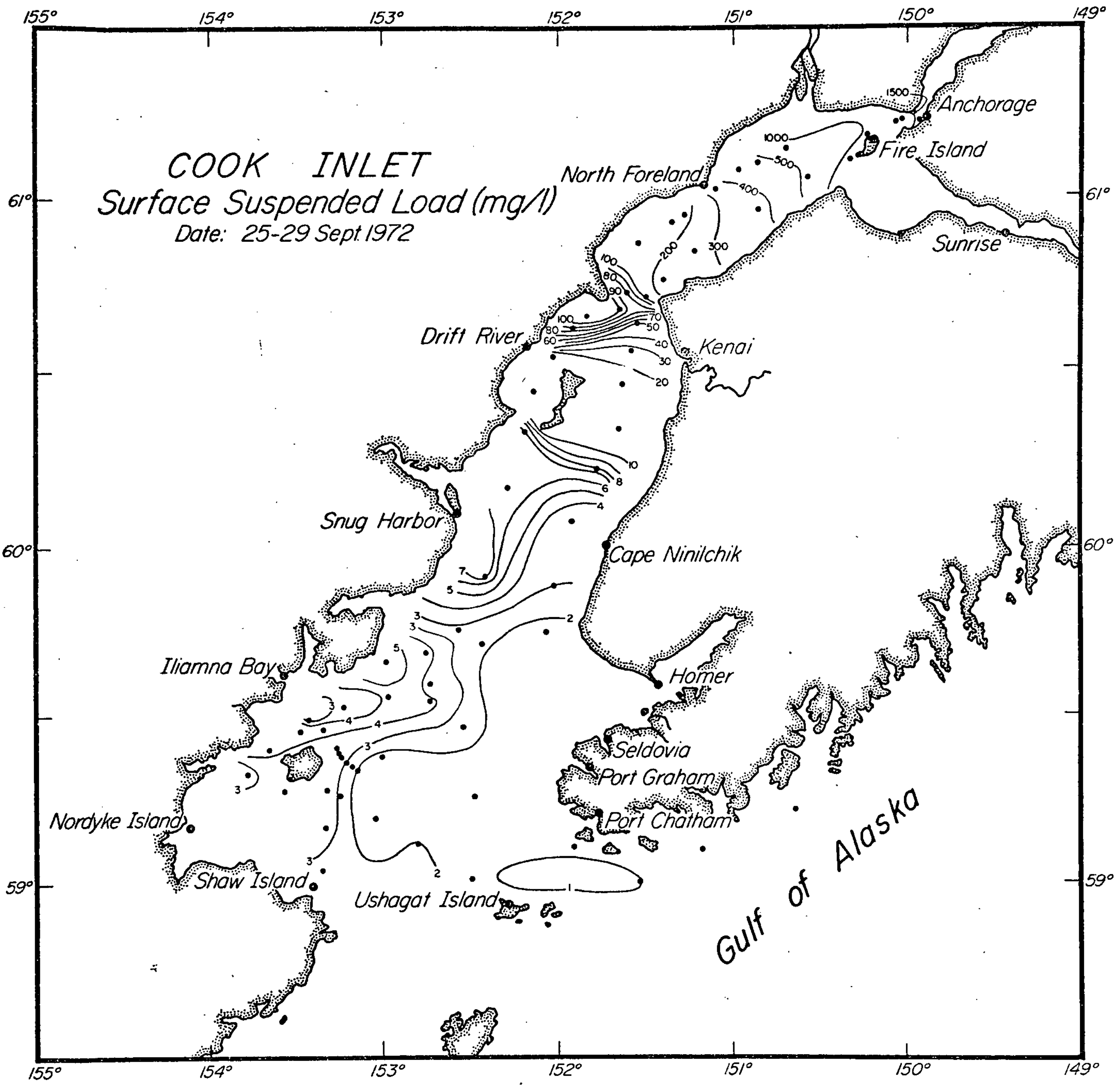

Figure 7. Suspended load distribution (mg/l) in surface waters of Cook Inlet, Alaska during 25-29 September 1972.

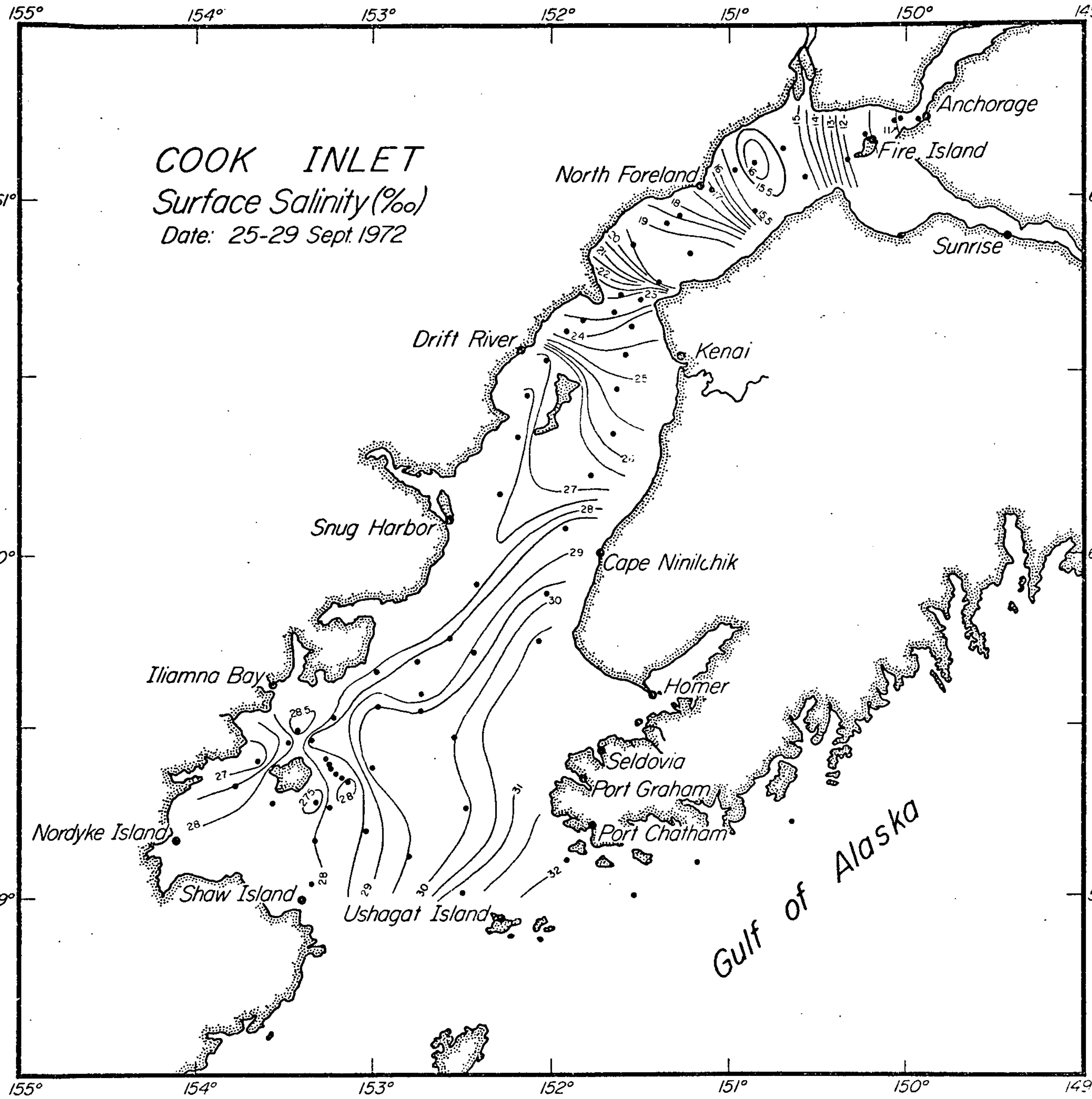

Figure 8. Surface water isohalines ($^{o}/oo$) in Cook Inlet, Alaska; 25-29 September 1972.

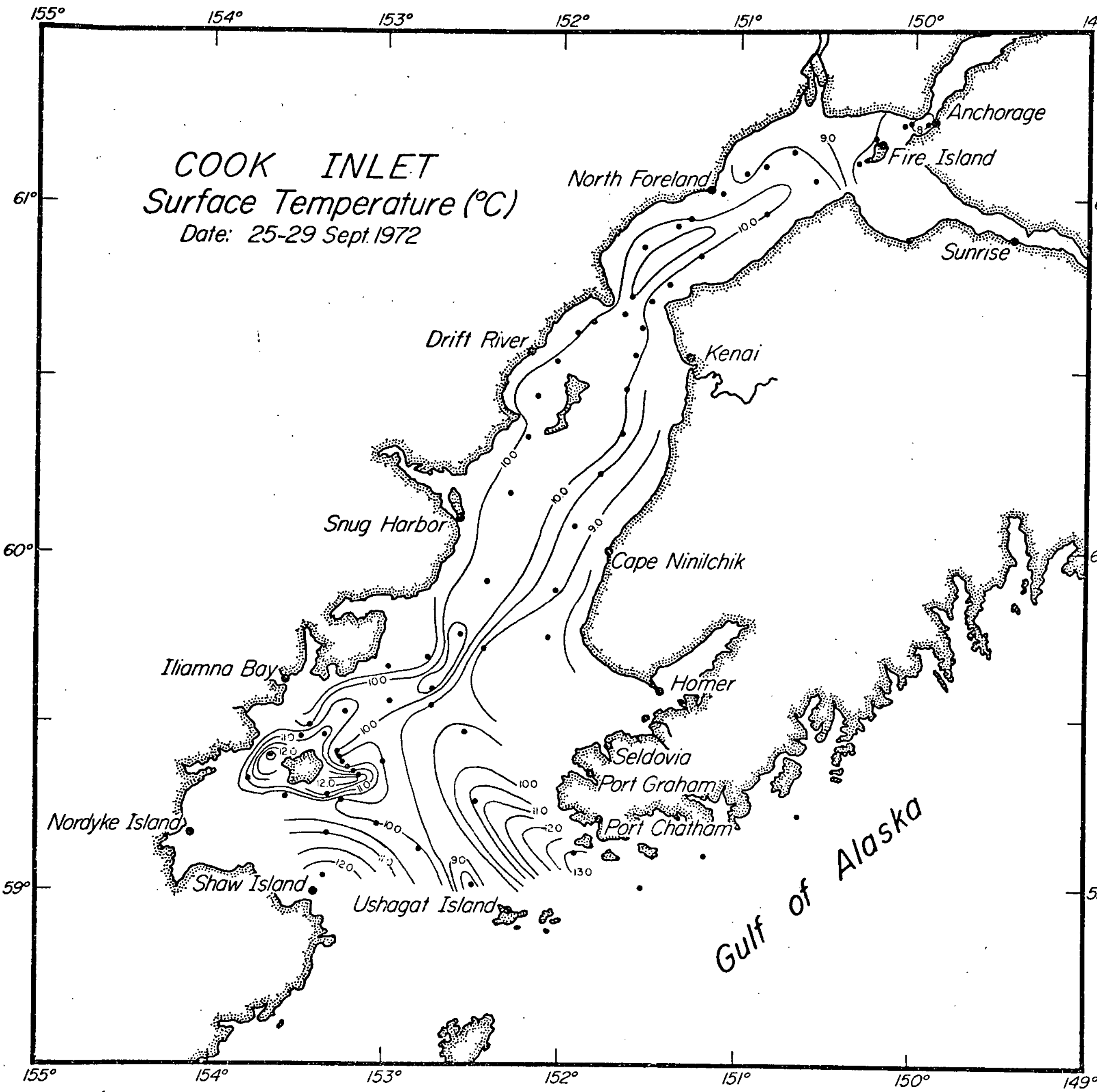

Figure 9. Surface water isotherms (°C) in Cook Inlet, Alaska; 25-29 September 1972.

the Bering Strait region during late November or early December; maximum ice extention in late February or March; disintegration and northward movement in April through June; and an ice-free season in July or early August through November. Thus, the initial phase of ERTS-A (operating to a cut off date of 5 November), was unable to obtain all the desired data. However, commencing on 15 February 1973, it is anticipated that the desired data will be available for the most critical period of the year (late winter through early summer) and that we will be able to document the seasonal changes and areal extent of different ice zones.

c. Kuskokwim Bay and Nushagak Bay Studies

Relatively cloud free ERTS-1 imagery from these areas was received during late Fall. These images (1039-21371, Aug 31, 72 from Kuskokwim Bay; and 1054-21203, Sept. 15, 72 from Nushagak Bay) show distinctly the extent of river plumes. Comparison of MSS-4, MSS-5, MSS-6, and MSS-7 revealed submerged beaches and thus provided information concerning the water depth penetration of MSS-4 and MSS-5 bands (Figs. 10 and 11). The configuration of the plume suggests anticlockwise circulation in Bristol Bay resulting from the tidal current and Coriolis effect. Comparison of MSS-7 band imagery with the most recent U.S. Coast and Geodetic Survey chart number 9302 prepared in Feb. 1971 and U.S. Geological Survey topographic maps show visible changes in the coastline. These changes reflect the dynamic state of the processes affecting the coastline. Such comparison over a period of time will provide insight concerning coastal processes and long term shore morphology and coastal development.

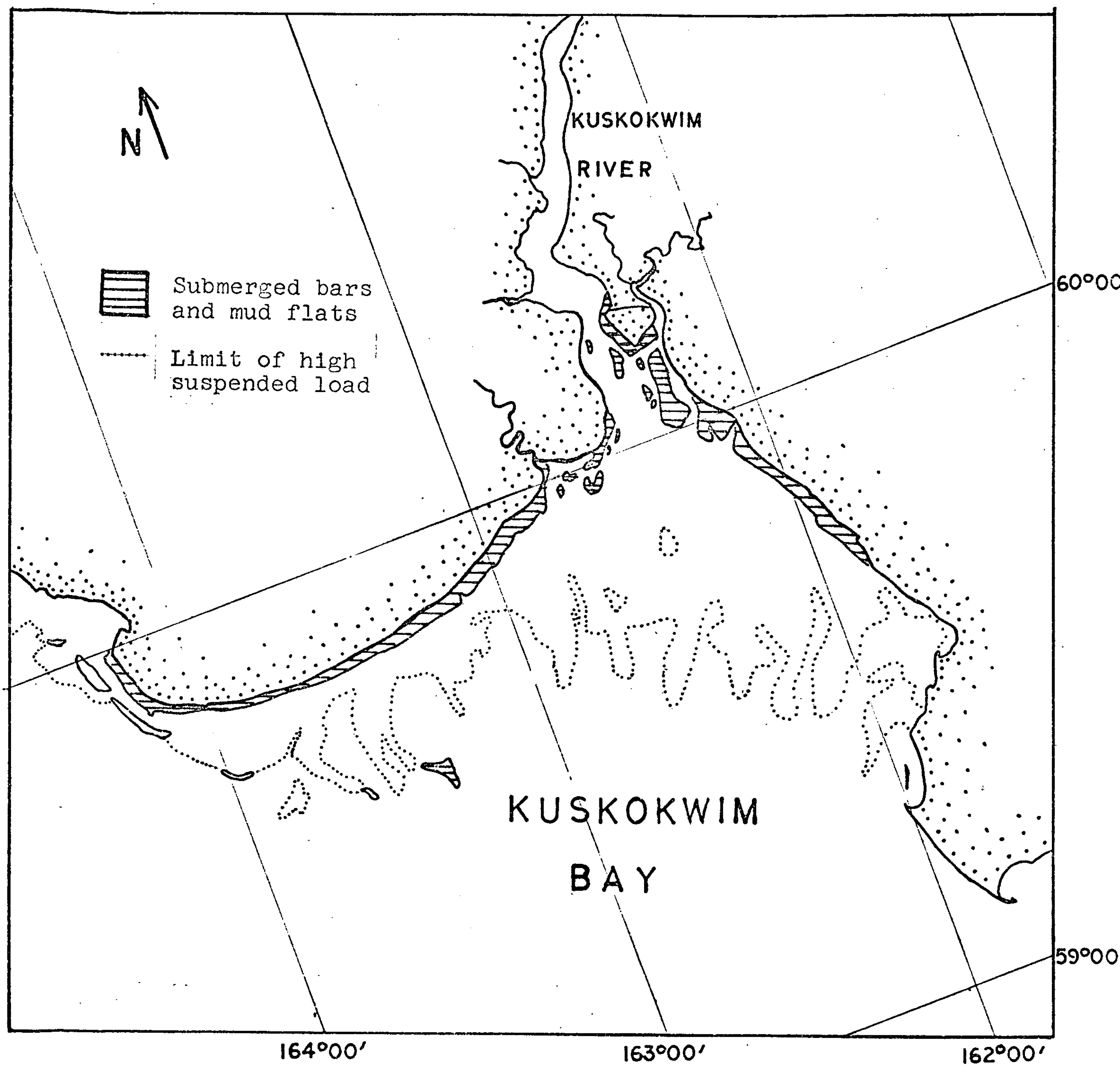

Figure 10. Delineation of the suspended sediment plume in Kuskokwim Bay, Alaska, on 31 Aug. 1972, based upon ERTS-1 imagery (ID 1039-21371, MSS bands 5 and 6).

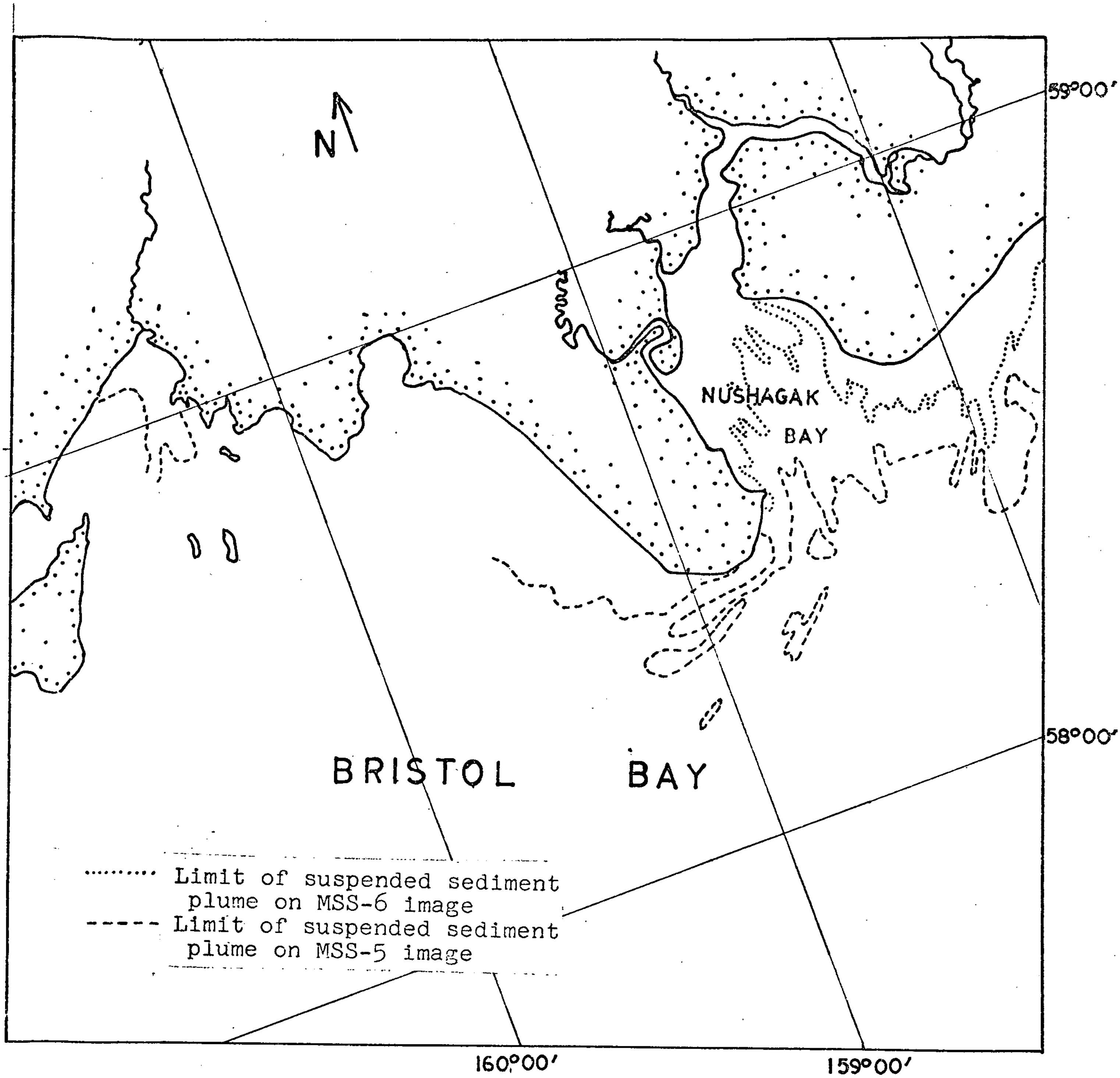

Figure 11. Delineation of the suspended sediment plume in Nushagak Bay, Alaska, on 15 Sept. 1972, based upon ERTS-1 imagery (ID 1054-21203).

2. Applicability of ERTS-1 Data to Project Objectives

Alaska has a larger coastline than the contiguous United States, most of which is remote from population centers. This remoteness coupled with the severe climate greatly limits collection of oceanographic information needed to understand the movement of water and sediments and the morphology of the shores. During winter months the Arctic and parts of the Bering Sea are covered by sea and shore ice. The formation and movement of ice in these regions affects ocean productivity, mammal migration and sediment transport.

Conventional oceanographic data collection methods to provide year round study of the Alaskan coast are costly and would require enormous manpower. To obtain oceanographic data, even from relatively small regions like Bristol Bay, requires several weeks during which many meteorological and hydrological changes occur. Surficial changes are generally dominated by tidal cycle and related currents. Data collected therefore includes variability caused by temporal processes and it is not possible to eliminate their effects in the final analysis of data.

The ERTS-1 imagery is unique because it provides a means to study large and at times relatively inaccesible areas. Furthermore it provides "instant" data for surface water properties which is free from variations caused by time lags between stations. The ERTS-1 imagery permits synoptic study of surface sediment, sea water and ice movements in Alaskan coastal areas.

Although we have not been successful in obtaining ground truth synchronous with overhead satellite passes, a striking similarity between ground observations and the satellite imagery has been clearly observed. Water properties in ERTS-1 imagery have been further enhanced by developing an intermediate negative using either 70 mm negatives or positives. Excellent delineation of the water properties also can be brought out by color differentiation and will be extensively used in future work.

Photographic processing of the available useful ERTS-1 imagery of Cook Inlet reliably shows the gross features of circulation. Upon acquisition of synchronous data it is intended to utilize the density-slicing technique to distinguish between waters of varying turbidity, and possibly other techniques to pin-point areas of high turbulence. As they stand, the Cook Inlet data not only display the basic circulation but also, since the turbid, traceable waters originate in the Anchorage area, show nicely the potential trajectory of industrial and domestic pollution from Anchorage (Alaska's population center) and from the petroleum production and processing facilities of the upper inlet.

The usefulness of ERTS-1 imagery to sea ice study is invaluable because of the ability to monitor the ice movement in the Arctic Ocean and Bering Sea. These images provide information concerning formation and location of sea ice over a large area. Such information is not easily available by conventional methods.

3. Results

A. Cook Inlet

Water temperature and salinity values for Cook Inlet cover a fairly broad range of values, but are certainly not unusual for high latitude estuarine situations. The suspended sediment values, however, are of particular interest. They may range over 1500 mg/ℓ in the surface waters of the open inlet, values comparable to the highest values measured in the fjords of Southeastern Alaska (Wright, 1971a). This suspended material is, of course, the largely mechanically abraded debris transported by glacial meltwater streams. It consists very largely of finely comminuted quartz, the bulk of which is in the silt size range but often contains material as coarse as fine sand or as small as the clay fraction. The percentage clays in this material is quite variable and mineralogically they tend toward illites (Sharma and Burrell, 1970). Such suspended sediment produces the highly turbid waters that are sometimes referred to as "glacial flour." When this turbid water enters the sea it may persist as discrete layers on or in the water column for a considerable time (Wright, 1971b). It is this turbid water which forms very distinctive plumes that permit ERTS observation of the details of inshore circulation.

As noted above, no ERTS data were obtained at the time of ground truth observations. Cloudiness prevented the collection of useful imagery until early November of 1972, when excellent images were made (Figs. 12 and 13). These show a striking pattern of surface circulation. The turbid waters introduced by glacial meltwater streams and rivers, mostly towards the head of the inlet, completely dominate the surface for the upper two-thirds of the inlet, and along the west shore of the entire inlet. Clear sea water intruded at the time of the images to almost Cape Ninilchik on the east shore of the inlet (Fig. 13). Judging from ground truth experience along the east shore, we are seeing turbid water that is actually below the surface, possibly at a depth of as much as two meters. At the surface in this season, clean surface waters often intrude as far north as Kenai where there are local sources of turbid waters (Fig. 4).

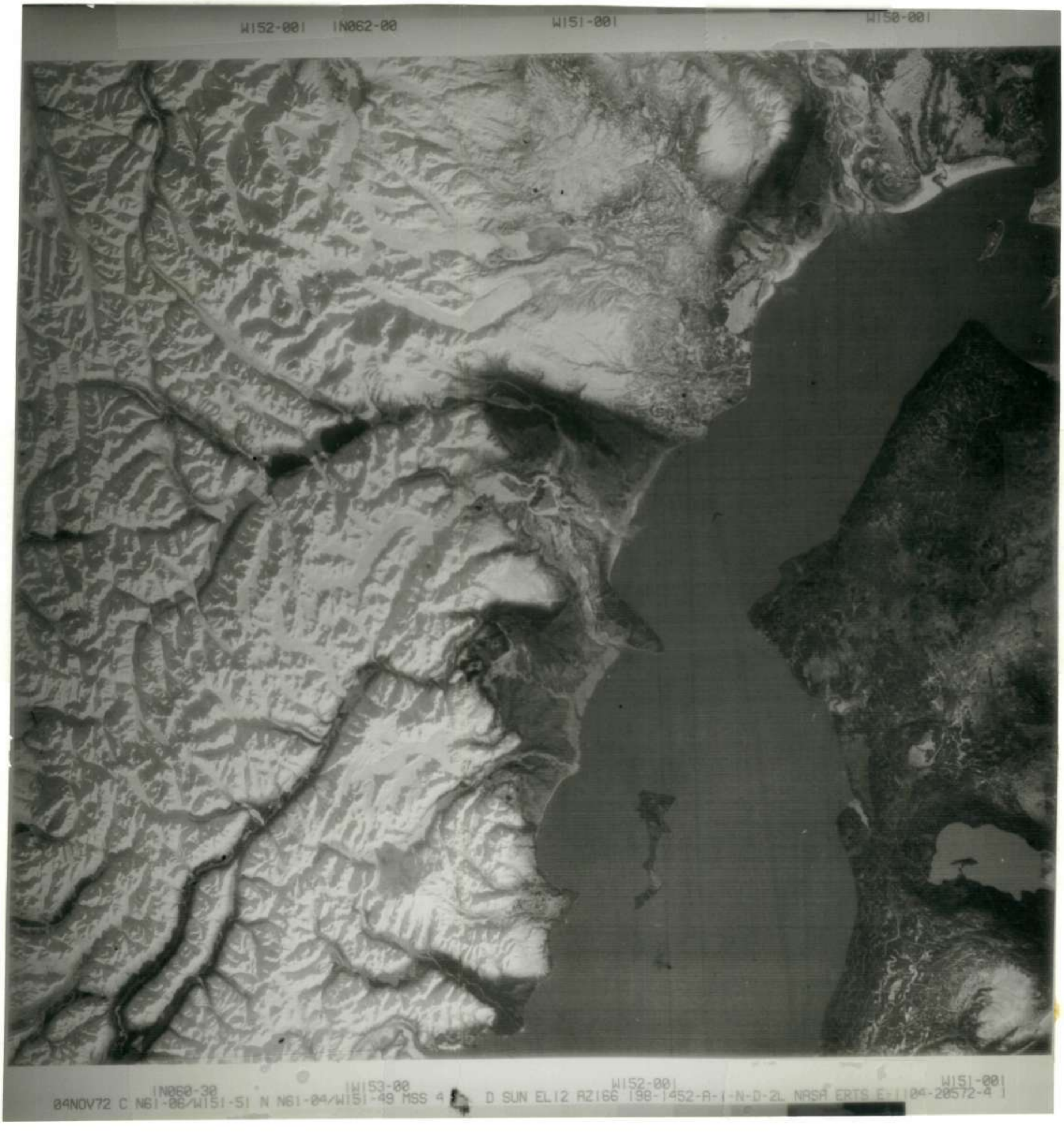

Figure 12. ERTS-1 image in MSS-4 band showing turbid waters in upper Cook Inlet, Alaska.

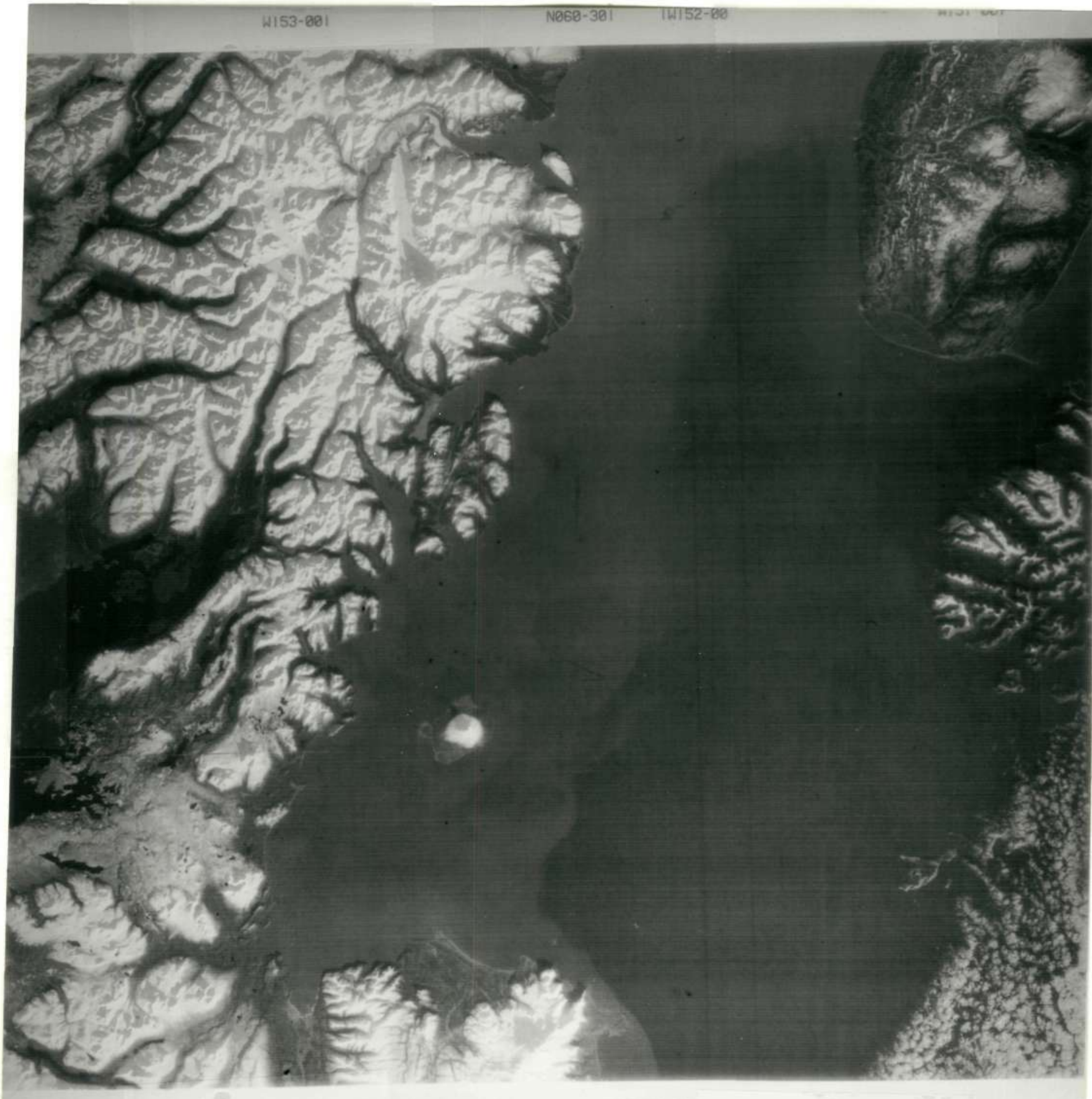

Figure 13. ERTS-1 image in MSS-4 band showing distribution of turbid and clear sea waters in lower Cook Inlet, Alaska.

The ERTS data, in conjunction with ground truth, permit the clear interpretation of the circulation system in the inlet.

The turbid, fresh water inflow to Cook Inlet serves as a tracer to the circulation. The bulk of the turbid waters are introduced from the Knik and Matanuska Rivers above Anchorage in the most northern portion of the inlet. In this portion of the inlet, basin geometry tends to amplify the tidal range and in the vicinity of Anchorage a diurnal range of approximately 10 m (30 ft.) is commonly observed. As well, in the Turnagain Arm just south of Anchorage, a tidal bore with a height as great as five feet frequently occurs. The result is the formation of a very homogeneous water mass in the immediate vicinity of Anchorage. This mass of water, under the influence of high amplitude mixed tides, is continually moving down the inlet toward the open sea. Coriolis influence at these latitudes is profound, and the pattern that we observe in ERTS imagery and ground truth simply reflects the tendency of moving water masses to show a deflection towards the right due to the earth's rotation.

B. Chukchi Sea

Sea ice analysis of available photos (August 1 through 4 and October 18) from the Chukchi Sea were exceptionally rewarding. It was possible to clearly delineate and describe the ice types apparent in the photos. The ice types ranged from newly formed "grease ice" to heavy flows of disintegrating shore-fast ice. Work with the available photos indicated that the objectives of this sub-program can be attained, even extending to the construction of maps showing the extent of different ice zones.

A considerable amount of interest has been generated by the limited imagery available to date. A working group of scientists interested in sea ice has been formed, with regularly scheduled meetings. The intent of this scientific group is to direct attention to the study of seasonal sea ice in a multi-disciplinary frame work ranging from physical properties to biological effects of ice. ERTS imagery will provide a basic and continuing source of data.

A considerable amount of ground truth data was obtained during the first six months of this project. On-going studies of marine mammal biology were continued. These provided data on the movements and distribution of marine mammals as well as low level photographs, taken from aircraft, of the limited ice covered areas included in ERTS photos. The ground truth data available indicates a high degree of accuracy in interpreting the ERTS photos.

Although the first phase of this project did not result in any quantity of data concerning sea ice, it did provide excellent photos of the northwest coast of Alaska, the off-shore islands and the eastern coast of the Chukchi Peninsula. These photos have been used in a preliminary study to compare the characteristics of coastal areas utilized by marine mammals.

C. Kuskokwim Bay and Nashagak Bay

The analyses of ERTS-1 imagery (ID 1039-21371 and 1054-21203) show major sources for sediments in this region. The distribution of sediments reveals the sediment transport and major sedimentary pathways. The configuration of sediment plumes is indicative of the surface water circulation, and shows a counterclockwise gyre in Bristol Bay. The movement of sediments in suspension along the northern shores of Bristol

Bay suggests a strong influence of Coriolis force on the water movement in this region.

The comparison of MSS bands 4, 5, 6, and 7 suggest that MSS-4 is capable of penetration of several meters into the water column. While band 7 provides the well defined shoreline the MSS 4 and 5 reveal submerged shallow beaches and bars (Figure 10). Synoptic studies of such features should delineate the movement of coastal bars seasonally and after severe storms in particular. Such studies would shed light on the processes which control the shoreline morphology and sediment transport on the shallow shelf areas. The ERTS-1 imagery from Kuskokwim Bay and Nushagak are very useful aids in planning the forthcoming field work in these areas.

III. NEW TECHNOLOGY

None.

IV. PLANS FOR NEXT REPORTING PERIOD

February-March Bimonthly Period

During the month of February water samples from the Copper River delta region in the Gulf of Alaska were collected for analysis. Salinity and temperature measurements of surface waters obtained should delineate the circulation of surface waters. This study was initiated in cooperation with the ongoing ERTS 110-9 project at the Institute of Marine Science. The data was collected onboard R/V ACONA and at no cost to the ERTS project.

ERTS-1 imagery obtained from the Chukchi Sea, received during September and October 1972, is being screened for sea ice studies. Interpretation of various sea ice characteristics is currently under way. The interpretation will be superimposed upon aerial observations obtained by Mr. Burns. This study is being conducted at no cost to the project.

February-July Six Month Period

Extensive analysis of ERTS-1 imagery has been severely restricted by the limited funds available in the budget for services. After a definite correlation between ERTS-1 imagery and ground truth data has been established photo interpretation, color separation and density slicing will be performed on all cloud free ERTS-1 imagery showing sediment distribution. New equipment on order would perform density slicing at a relatively low cost and the analysis will proceed as soon as the display equipment becomes available.

Sea ice characteristics and distribution will be studied as ERTS-1 imagery becomes available. The data obtained will be correlated to ground truth and the mammal population in the Bering and Chukchi Seas.

V. CONCLUSIONS

The basic utility of ERTS MSS data for the clarification of circulation and mammal distribution problems in Alaska has been demonstrated. Even at the present superficial level of analysis and with only fragmented data, many of the broad features (those aspects most difficult to distinguish on the ground) become very obvious. In the Cook Inlet situation, a number of conclusions based upon ERTS and ground truth can already be reached:

1) The turbid glacial waters of the upper inlet can readily be traced on the surface with ERTS imagery.
2) The turbid waters can thus serve as a tracer for pollutants, both industrial and domestic, from the Anchorage area.
3) MSS data was apparently obtained from some depth in the water column, and refined data processing techniques may permit the segregation of this non-surface data.
4) The extent of surface, as opposed to bed-load sediment transport in the system is extremely clear.
5) Based upon sea ice analysis of the limited data available to date, prospects of achieving our program goals during the late winter through summer period appear excellent.

VI. RECOMMENDATIONS

None.

VII. PUBLICATIONS

Wright, F. F., Sharma, G. D., and Burbank, D. C., ERTS-1 Observations of Sea Surface Circulation and Sediment Transport, Cook Inlet, Alaska, ERTS-1 Symposium, March, 1973.

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APPENDIX A - CHANGE IN STANDING ORDER FORMS

Original order date: 6/20/72
Revised order date: 11/07/72
Revised order date: 3/19/73

APPENDIX B - ERTS DATA REQUEST FORMS

None

ERTS IMAGE DESCRIPTOR FORM

(See Instructions on Back)

NDPF USE ONLY
D
N
ID

DATE February 15, 1973

PRINCIPAL INVESTIGATOR G. D. Sharma

GSFC UN 683

ORGANIZATION University of Alaska

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS	
	Coast	Estuary	Shelf	River	Sediment Plume
1198-20572M	X	X	X	X	X
1198-20574M	X	X	X	X	X

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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SEMI-ANNUAL PROGRESS REPORT
UNIVERSITY OF ALASKA
ERTS PROJECT 110-8
March 15, 1973

PRINCIPAL INVESTIGATOR: G. D. Sharma and F. F. Wright

TITLE OF INVESTIGATION: Sea ice and surface water circulation, Alaskan continental shelf.

DISCIPLINE: Marine Geology and Ecology

SUMMARY OF SIGNIFICANT RESULTS:

Even though non-synchronous, the ERTS-1 imagery of November 4, 72 showed a striking similarity to the ground truth data obtained late August and September, 72. The comparison of the images with ground truth data revealed that the general water circulation pattern in Lower Cook Inlet is consistent through the Fall season and that ERTS-1 images in MSS bands 4 and 5 are capable of delineating water masses with a suspended load as low as 1 mg/ℓ.

The ERTS-1 data and the ground truth data demonstrate clearly that the Coriolis effect dominates circulation in Lower Cook Inlet. The configuration of plumes in Nushagak and Kuskokwim bays further indicate the influence of the Coriolis effect on the movement of sea water at high latitudes.

Comparison of MSS bands 4, 5, 6 and 7 suggest MSS-4 penetration of several meters into the water column.

Sea ice analysis of available imagery was exceptionally rewarding. The imagery provided a rapid method to delineate and describe the ice types

apparent in the photos. The ice types ranged from newly formed "grease ice" to heavy flows of disintegrating shore-fast ice. Sea ice maps showing the extent of different ice zones in the Chukchi Sea are being compiled.

ERTS 1 STANDING ORDER FORM
(See Instructions on Back)

DATE March 19, 1973

GSFC ID NUMBER U683/U15

PRINCIPAL INVESTIGATOR Frederick F. Wright

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☐ ADDITION
☒ CHANGE
☐ DELETION

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CATALOGS DESIRED
STANDARD ☐ U.S. ☐ NON-U.S.
DCS ☐
MICROFILM ☐ U.S. ☐ NON-U.S.
☐ CHECK IF ADDRESS IS NEW

AREA NUMBER	GEOGRAPHIC POINTS: LATITUDE	GEOGRAPHIC POINTS: LONGITUDE	CLOUD COVER %	QUALITY	COVERAGE PERIOD: START DATE	COVERAGE PERIOD: STOP DATE	PROD: TYPE	PROD: FORMAT	TICK MARK	QUANTITY	RBV BANDS 1	RBV BANDS 2	RBV BANDS 3	MSS BANDS 1	MSS BANDS 2	MSS BANDS 3	MSS BANDS 4	DELETE
FROM	58°00'N	154°00'W	3		021573	111573		M		2	X	X	X	X	X	X	X	
	62°00'N	152°00'W						S		2	X	X	X	X	X	X	X	
	62°00'N	149°00'W						P		2	X	X	X	X	X	X	X	
	58°00'N	149°00'W																
	62°30'N	176°00'W	5		021573	111573		M		3	x	x	x	x	x	x	x	
	65°30'N	169°00'W						S		3	x	x	x	x	x	x	x	
	65°00'N	160°00'W						P		3	x	x	x	x	x	x	x	
	58°00'N	156°00'W																
	54°00'N	166°00'W																
	52°00'N	176°00'W																
	72°00'N	172°00'W	5		021573	111573		M		3	X	X	X	X	X	X	X	
	72°00'N	156°00'W						S		3	X	X	X	X	X	X	X	
	65°00'N	160°00'W						P		3	X	X	X	X	X	X	X	
	65°30'N	172°00'W																
TO	56°00'N	156°00'W	3		021573	111573		M		2				X	X	X	X	
	60°00'N	154°00'W						S		2				X	X	X	X	
	62°00'N	152°00'W						P		2				X	X	X	X	
	62°00'N	148°00'W																
	60°00'N	144°00'W																
	52°00'N	175°00'E	4		021573	111573		M		3				X	X	X	X	
	66°00'N	172°00'W						S		3				X	X	X	X	
	66°00'N	160°00'W						P		3				X	X	X	X	
	59°30'N	156°00'W																
	52°00'N	160°00'W																
	Continued on next page																	

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